

4.2 Surface Water and Sediment Surveillance

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Samples of surface water and sediment on and near the Hanford Site were collected and analyzed to determine the potential impact to the public and to the aquatic environment from Hanford-originated radiological and chemical contaminants. Surface-water bodies included in routine surveillance were the Columbia River and associated riverbank springs, onsite ponds, and irrigation sources. Sediment surveillance was conducted for the Columbia River and

riverbank springs. Tables 4.2.1 and 4.2.2 summarize the sampling locations, types, frequencies, and analyses included in surface water and sediment surveillance activities during 2000. Sampling locations are identified in Figure 4.2.1. This section describes the surveillance effort and summarizes the results for these aquatic environments. Detailed analytical results are reported in PNNL-13487, APP. 1.

4.2.1 Columbia River Water

The Columbia River is the second largest river in the continental United States in terms of total flow and is the dominant surface-water body on the Hanford Site. The original selection of the Hanford Site for plutonium production and processing was based, in part, on the abundant water supply offered by the river. The river flows through the northern edge of the site and forms part of the site's eastern boundary. The river is used as a source of drinking water for onsite facilities and communities located downstream from the Hanford Site. Water from the river downstream of the site also is used for crop irrigation. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities, including hunting, fishing, boating, water-skiing, and swimming.

Originating in the mountains of eastern British Columbia, the Columbia River and its tributaries drain an area of ~670,000 square kilometers (260,000 square miles) en route to the Pacific Ocean. The flow of the river is regulated by three dams in Canada and eleven dams in the United States, seven upstream and four downstream of the Hanford Site. Priest Rapids Dam is the nearest upstream dam and

McNary Dam is the nearest downstream dam from the site. The Hanford Reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula (created by McNary Dam) near Richland, Washington. The Hanford Reach is the last stretch of the Columbia River in the United States above Bonneville Dam that remains unimpounded.

River flow through the Hanford Reach fluctuates significantly and is controlled primarily by operations at Priest Rapids Dam. Annual average flows of the Columbia River below Priest Rapids Dam are nearly 3,400 m³ (120,000 ft³) per second (WA-94-1). In 2000, the Columbia River had normal flows; the average daily flow rate below Priest Rapids Dam was 3,400 m³ (120,000 ft³) per second. The peak monthly average flow rate occurred during May (4,640 m³ [164,000 ft³] per second) (Figure 4.2.2). The lowest monthly average flow rate occurred during October (2,190 m³ [77,200 ft³] per second). Daily flow rates varied from 1,210 to 6,600 m³ (42,400 to 233,000 ft³) per second during 2000. As a result of fluctuations in discharges, the depth of the river varies significantly over time. River stage (surface level) may change along the Hanford Reach by up to 3 meters (10 feet)



Table 4.2.1. Surface-Water Surveillance, 2000

<u>Location</u>	<u>Sample Type</u>	<u>Frequency^(a)</u>	<u>Analyses</u>
Columbia River - Radiological			
Priest Rapids Dam and Richland Pumphouse	Cumulative	M Comp ^(b) Q Comp ^(e)	Alpha, beta, lo ³ H, ^(c) ⁹⁰ Sr, ⁹⁹ Tc, U ^(d) ¹²⁹ I
	Particulate (filter)	M Cont ^(f) Q Cont ^(g)	Gamma energy analysis Pu ^(h)
	Soluble (resin)	M Cont Q Cont	Gamma energy analysis Pu
Vernita Bridge and Richland Pumphouse	Grab (transects)	Q	lo ³ H, ⁹⁰ Sr, U
100-F, 100-N, 300, and Old Hanford Townsite	Grab (transects)	A	lo ³ H, ⁹⁰ Sr, U
Columbia River - Non-Radiological			
Vernita Bridge and Richland Pumphouse ⁽ⁱ⁾	Grab	Q	NASQAN, temperature, dissolved oxygen, turbidity, pH, alkalinity, anions, suspended solids, dissolved solids, specific conductance, hardness (as CaCO ₃), Ca, P, Cr, Mg, N-Kjeldahl, Fe, NH ₃ , NO ₃ + NO ₂
	Grab (transects)	Q	ICP ^(j) metals, anions
	Grab (transects)	A	Cyanide (CN ⁻), VOA ^(k)
100-F, 100-N, 300, and Old Hanford Townsite	Grab (transects)	A	ICP metals, anions
Onsite Ponds			
West Lake	Grab	Q	Alpha, beta, ³ H, ⁹⁰ Sr, ⁹⁹ Tc, U, gamma energy analysis
Fast Flux Test Facility pond	Grab	Q	Alpha, beta, ³ H, gamma energy analysis
Offsite Irrigation Water			
Riverview irrigation canal	Grab	3/year	Alpha, beta, ³ H, ⁹⁰ Sr, U, gamma energy analysis
Horn Rapids	Grab	A	Alpha, beta, ³ H, ⁹⁰ Sr, U, gamma energy analysis
Riverbank Springs			
100-H Area	Grab	A	Alpha, beta, ³ H, ⁹⁰ Sr, ⁹⁹ Tc, U, gamma energy analysis, ICP metals, anions
100-F Area	Grab	A	Alpha, beta, ³ H, ⁹⁰ Sr, U, gamma energy analysis, ICP metals, anions, VOA
100-B Area	Grab	A	Alpha, beta, ³ H, ⁹⁰ Sr, ⁹⁹ Tc, gamma energy analysis, ICP metals, anions, VOA
100-D, 100-K, and 100-N Areas	Grab	A	Alpha, beta, ³ H, ⁹⁰ Sr, gamma energy analysis, ICP metals, anions, VOA (100-K Area only)
Old Hanford Townsite	Grab	A	Alpha, beta, ³ H, ¹²⁹ I, ⁹⁰ Sr, ⁹⁹ Tc, U, gamma energy analysis, ICP metals, anions
300 Area	Grab	A	Alpha, beta, ³ H, ¹²⁹ I, ⁹⁰ Sr, gamma energy analysis, ICP metals, anions, VOA

(a) A = Annually; M = Monthly; Q = Quarterly; Comp = Composite.

(b) M Comp indicates river water was collected hourly and composited monthly for analysis.

(c) lo ³H = Low-level tritium analysis (10-pCi/L detection limit), which includes an electrolytic preconcentration.

(d) U = Isotopic uranium-234, -235, and -238.

(e) Collected weekly and composited for quarterly analysis.

(f) M Cont = River water was sampled for 2 wk by continuous flow through a filter and resin column and multiple samples were composited monthly for analysis.

(g) Q Cont = River water was sampled for 2 wk by continuous flow through a filter and resin column and multiple samples were composited quarterly for analysis.

(h) Pu = Isotopic plutonium-238 and -239/240.

(i) Numerous water quality analyses are performed by the U.S. Geological Survey in conjunction with the National Stream Quality Accounting Network (NASQAN) Program.

(j) ICP = Inductively coupled plasma analysis method.

(k) VOA = Volatile organic compounds.

Table 4.2.2. Sediment Surveillance, 2000

<u>Location^(a)</u>	<u>Frequency</u>	<u>Analyses</u>
River		All river sediment analyses included gamma energy analysis, ⁹⁰ Sr, U ^(b) , Pu ^(c) , ICP ^(d) metals, SEM/AVS ^(e)
Priest Rapids Dam: 2 locations near the dam	A ^(f)	
White Bluffs Slough	A	
100-F Slough	A	
Hanford Slough	A	
Richland	A	
McNary Dam: 2 locations near the dam	A	
Springs^(g)		All springs sediment analyses included gamma energy analysis, ⁹⁰ Sr, U, ICP metals
100-B Area	A	
100-K Area	A	
100-N Area	A	
100-F Area	A	
Old Hanford Townsite Springs	A	
300 Area	A	

(a) See Figure 4.2.1.

(b) U = Uranium-235 and -238 analyzed by low-energy photon analysis.

(c) Pu = Isotopic plutonium-238 and -239/240.

(d) ICP = Inductively coupled plasma analysis method.

(e) SEM/AVS = Simultaneously extracted metals and acid volatile sulfide.

(f) A = Annually.

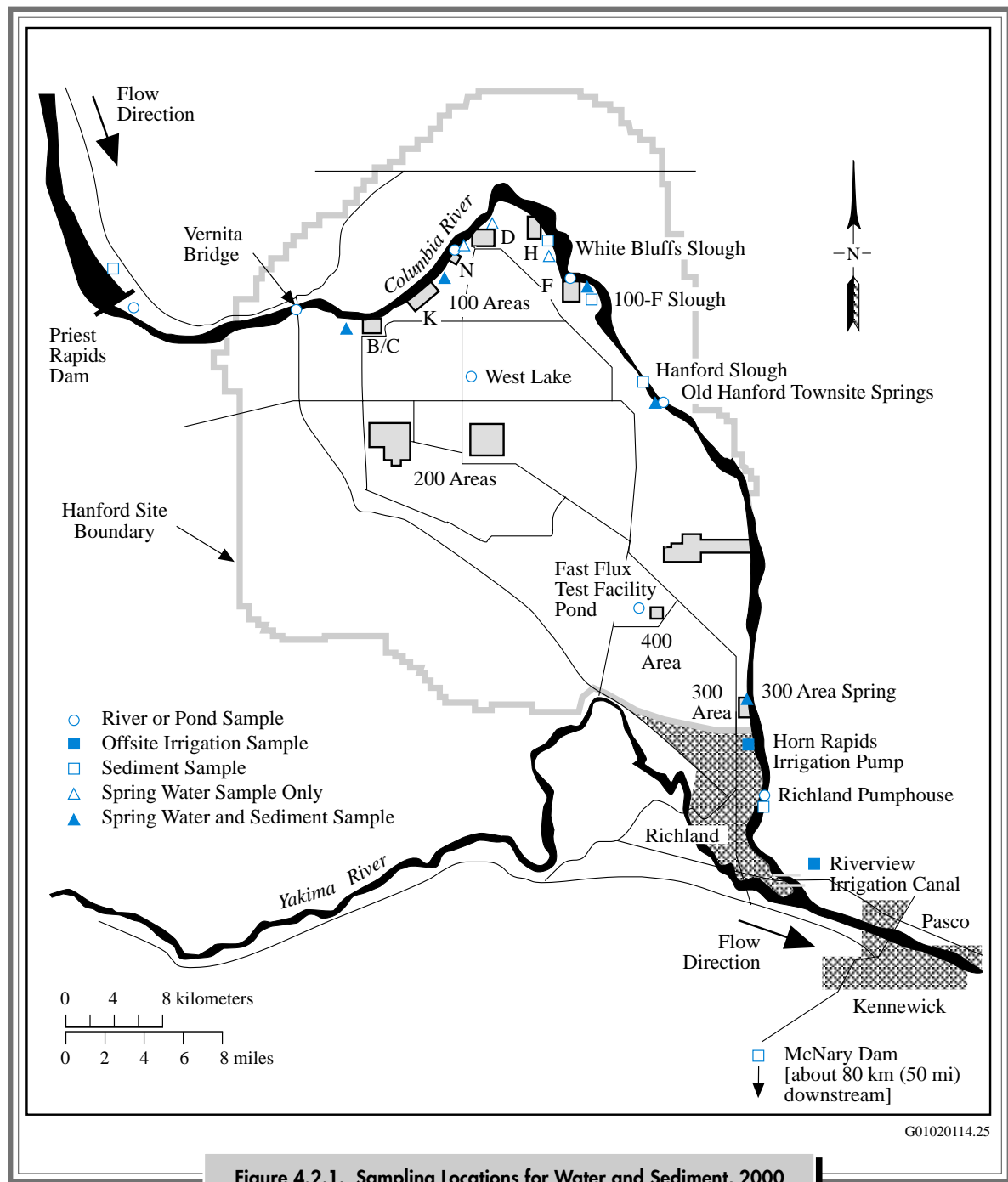
(g) Sediment is collected when available.

within a few hours (Section 3.3.7 in PNL-10698). Seasonal changes of approximately the same magnitude are also observed. River-stage fluctuations measured at the 300 Area are approximately half the magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam (PNL-8580) and the relative distance of each area from Priest Rapids Dam. The width of the river varies from ~300 to 1,000 meters (980 to 3,300 feet) through the Hanford Site.

Pollutants, both radiological and chemical, enter the Columbia River along the Hanford Reach. In addition to permitted direct discharges of liquid

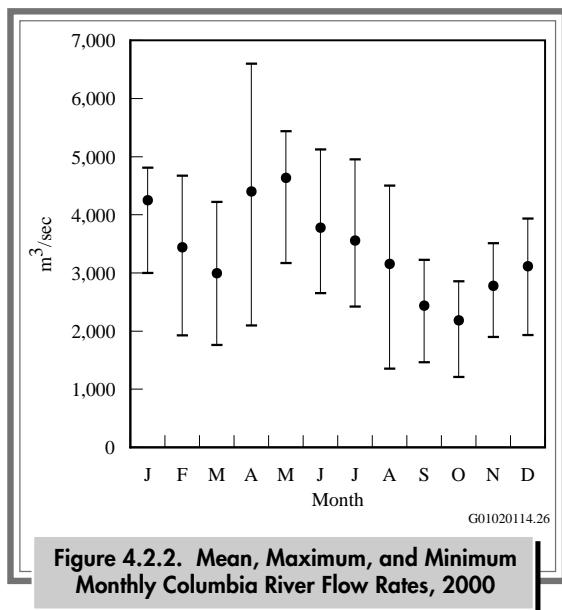
effluents from Hanford facilities, contaminants in groundwater from past operational discharges to the ground seep into the river (DOE/RL-92-12; PNL-5289; PNL-7500; WHC-SD-EN-TI-006). Effluents from each direct discharge point are monitored routinely and reported by the responsible operating contractor; these were summarized in Section 3.1. Direct discharges are identified and regulated for non-radiological constituents under the National Pollutant Discharge Elimination System in compliance with the *Clean Water Act*. The National Pollutant Discharge Elimination System-permitted discharges at the Hanford Site are summarized in Section 2.2.8.





Washington State has classified the stretch of the Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent (WAC

173-201A). Water quality criteria and water use guidelines have been established in conjunction with this designation and are provided in Appendix D (Table D.1).



4.2.1.1 Collection of River-Water Samples and Analytes of Interest

Samples of Columbia River water were collected throughout 2000 at the locations shown in Figure 4.2.1. Samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse and from Columbia River transects and near-shore locations near the Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse. Samples were collected upstream from Hanford Site facilities at Priest Rapids Dam and Vernita Bridge to provide background data from locations unaffected by site operations. Samples were collected from all other locations to identify any increase in contaminant concentrations attributable to Hanford operations. The Richland Pumphouse is the first downstream point of Columbia River water withdrawal for a municipal drinking water supply.

The fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse consisted of both an automated sampler and a continuous flow system. Using the automated sampler, unfiltered samples of Columbia River water (cumulative

samples) were obtained hourly and collected weekly. Weekly samples were composited monthly for radiological analyses (see Table 4.2.1). Using the continuous flow system, particulate and soluble fractions of selected Columbia River water constituents were collected by passing water through a filter and then through a resin column. Filter and resin samples were exchanged approximately every 14 days and were combined into quarterly composite samples for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in detail in DOE/RL-91-50.

Radionuclides of interest were selected for analysis based on

- their presence in effluents discharged from site facilities or in near-shore groundwater underlying the Hanford Site
- their importance in determining water quality, verifying effluent control and monitoring systems, and determining compliance with applicable standards.

Analytes of interest in water samples collected from Priest Rapids Dam and the Richland Pumphouse included gross alpha, gross beta, selected gamma emitters, tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, -238, plutonium-238, and plutonium-239/240. Gross alpha and beta measurements are indicators of the general radiological quality of the river and provide a timely indication of change. Gamma energy analysis provides the ability to detect numerous specific radionuclides (see Appendix F). Sensitive radiochemical analyses were used to determine the concentrations of tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, -238, plutonium-238, and plutonium-239/240 in river water during the year. Analytical detection levels for all radionuclides were less than 10% of their respective water quality criteria levels (see Appendix D, Tables D.1 and D.2).

Transect sampling (multiple samples collected along a line across the Columbia River) was initiated





as a result of findings of a special study conducted during 1987 and 1988 (PNL-8531). That study concluded that, under certain flow conditions, contaminants entering the river from the Hanford Site are not completely mixed when sampled at routine monitoring stations located downriver. Incomplete mixing results in a slightly conservative (high) bias in the data generated using the routine, single-point, sampling system at the Richland Pumphouse. In 1999, the transect sampling strategy was modified, with some of the mid-river sampling points shifted to near-shore locations in the vicinity of the transect. For example, at the 100-N Area instead of collecting ten evenly-spaced cross-river transect samples, only six cross-river samples were collected and the other four samples were obtained at near-shore locations. This sampling pattern allows the cross-river concentration profile to be determined and provides information over a larger portion of the Hanford shoreline where the highest contaminant concentrations would be expected. The Vernita Bridge and the Richland Pumphouse transects and near-shore locations were sampled quarterly during 2000. Annual transect and near-shore sampling was conducted at the 100-F Area, 100-N Area, Old Hanford Townsite, and 300 Area locations in the late summer when river flows were low.

Columbia River transect water samples collected in 2000 were analyzed for both radiological and chemical contaminants (see Table 4.2.1). Metals and anions (listed in DOE/RL-93-94) were selected for analysis following reviews of existing surface-water and groundwater data, various remedial investigation/feasibility study work plans, and preliminary Hanford Site risk assessments (DOE/RL-92-67; PNL-8073; PNL-8654; PNL-10400; PNL-10535). All radiological and chemical analyses of transect samples were performed on unfiltered water, except for metals analyses, which were performed on both filtered and unfiltered samples.

In addition to Columbia River monitoring conducted by Pacific Northwest National Laboratory in 2000, non-radiological water quality monitoring also

was performed by the U.S. Geological Survey. U.S. Geological Survey samples were collected along Columbia River transects quarterly at the Vernita Bridge and the Richland Pumphouse (Appendix B, Table B.5). Sample analyses were performed at the U.S. Geological Survey laboratory in Denver, Colorado for numerous physical parameters and chemical constituents.

4.2.1.2 Radiological Results for River-Water Samples

Fixed Location Sampling. Results of the radiological analyses of Columbia River water samples collected at Priest Rapids Dam and Richland Pumphouse during 2000 are reported in PNNL-13487, APP. 1 and summarized in Appendix B (Tables B.1 and B.2). These tables also list the maximum and mean concentrations of selected radionuclides detected in Columbia River water in 2000 and during the previous 5 years. All radiological contaminant concentrations measured in Columbia River water in 2000 were less than DOE derived concentration guides (DOE Order 5400.5) and Washington State ambient surface-water quality criteria (WAC 173-201A and 40 CFR 141) levels (see Appendix D, Tables D.5, D.3, and D.2, respectively). Significant results are discussed and illustrated below, and comparisons to previous years are provided.

Radionuclide concentrations monitored in Columbia River water were extremely low throughout the year. The radionuclides consistently detected in river water during 2000 included tritium, strontium-90, iodine-129, uranium-234, -238, plutonium-239/240, and naturally occurring beryllium-7 and potassium-40. The concentrations of all other measured radionuclides were below detection limits in more than 75% of samples collected. Tritium, strontium-90, iodine-129, and plutonium-239/240 exist in worldwide fallout, as well as in effluents from Hanford facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford Site effluents.

Figures 4.2.3 and 4.2.4 illustrate the average annual gross alpha and gross beta concentrations, respectively, at Priest Rapids Dam and Richland Pumphouse during the past 6 years. The 2000 average gross alpha and gross beta concentrations were similar to those observed during recent years. Monthly measurements at the Richland Pumphouse in 2000 were not statistically higher than those measured at Priest Rapids Dam. Unless otherwise noted in this section, the statistical tests for differences are paired sample comparisons and two-tailed t-tests, 5% significance level. The average alpha and beta concentrations in Columbia River water at the Richland Pumphouse in 2000 were less than the ambient surface-water quality criteria levels of 15 and 50 pCi/L, respectively.

Figure 4.2.5 compares the annual average tritium concentrations at Priest Rapids Dam and Richland Pumphouse from 1995 through 2000. Statistical analysis indicated that monthly tritium concentrations in river water samples at the Richland Pumphouse were higher than concentrations in

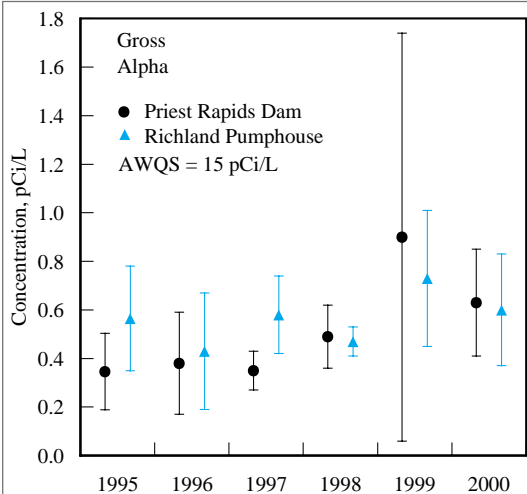


Figure 4.2.3. Annual Average Gross Alpha Concentrations (± 2 standard error of the mean) in Columbia River Water, 1995 through 2000 (AWQS = ambient water quality standard)

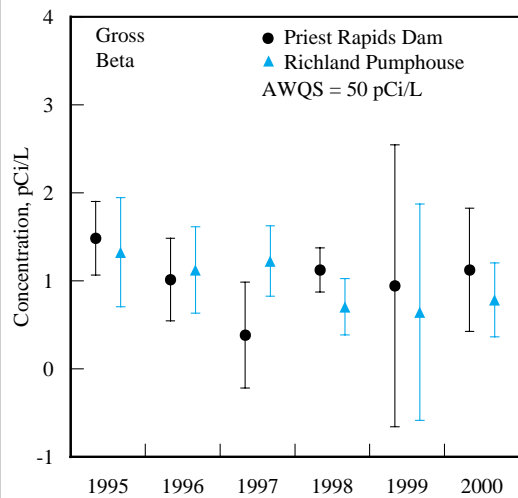


Figure 4.2.4. Annual Average Gross Beta Concentrations (± 2 standard error of the mean) in Columbia River Water, 1995 through 2000 (AWQS = ambient water quality standard)

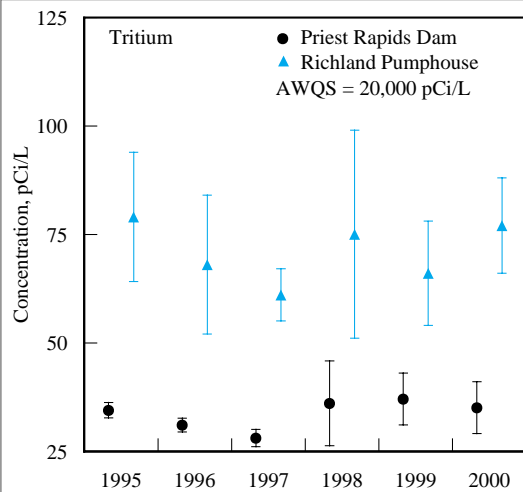


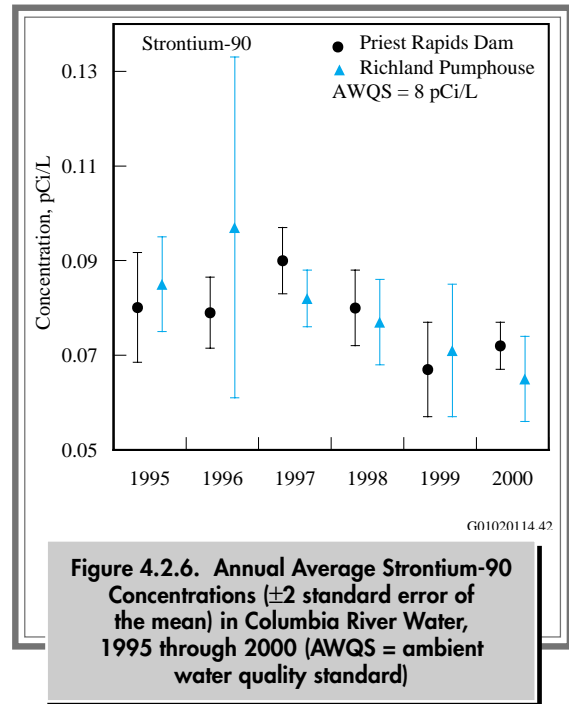
Figure 4.2.5. Annual Average Tritium Concentrations (± 2 standard error of the mean) in Columbia River Water, 1995 through 2000 (AWQS = ambient water quality standard)





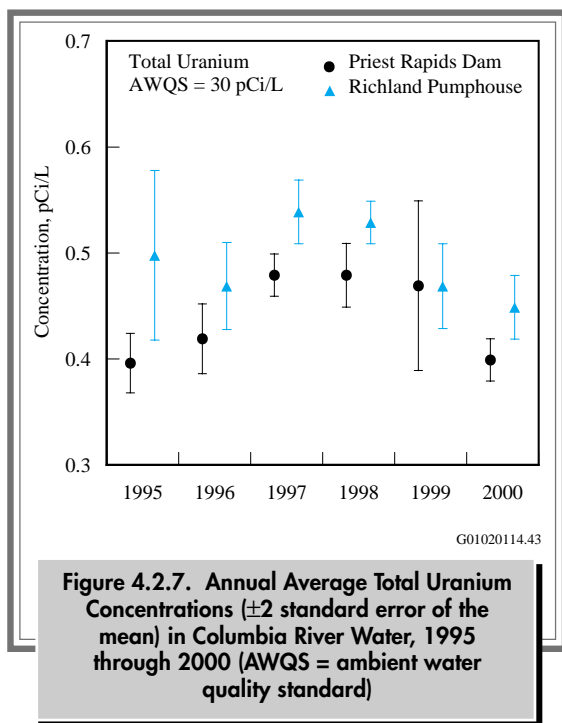
samples from Priest Rapids Dam. However, 2000 average tritium concentrations in Columbia River water collected at the Richland Pumpouse were only 0.4% of the ambient surface-water quality criteria level of 20,000 pCi/L. Onsite sources of tritium entering the river include groundwater seepage and direct discharge from permitted outfalls located in the 100 Areas (see Sections 3.1 and 7.1). Tritium concentrations measured at the Richland Pumpouse, while representative of river water used by the city of Richland for drinking water, tend to overestimate the average tritium concentrations across the river at this location (PNL-8531). This bias is attributable to the contaminated 200 Areas' groundwater plume entering the river along the portion of shoreline extending from the Old Hanford Townsite to below the 300 Area, which is relatively close to the Richland Pumpouse sample intake. This plume is not completely mixed within the river at the Richland Pumpouse. Sampling along cross-river transects at the pumpouse during 2000 confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken from the Richland Pumpouse overestimate the average tritium concentrations in the Columbia River at this location is variable and appears to be related to the flow rate of the river just before and during sample collection.

The annual average strontium-90 concentrations in Columbia River water collected from Priest Rapids Dam and Richland Pumpouse from 1995 through 2000 are presented in Figure 4.2.6. Levels observed in 2000 were similar to those reported previously. Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Areas (see Section 7.1.6.1). Some of the highest strontium-90 levels that have been found in onsite groundwater are the result of past discharges to the 100-N Area liquid waste disposal facilities. Despite the Hanford Site source, the differences between monthly strontium-90 concentrations at Priest Rapids Dam and Richland Pumpouse in 2000 were not statistically different.



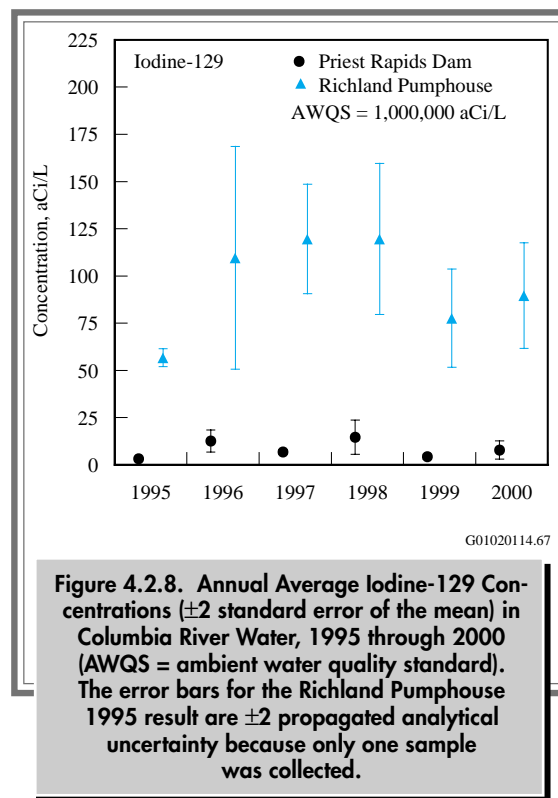
Average strontium-90 concentrations in Columbia River water at the Richland Pumpouse were less than 0.8% of the 8-pCi/L ambient surface-water quality criteria level.

Annual average total uranium concentrations (i.e., the sum of uranium-234, -235, -238) at Priest Rapids Dam and Richland Pumpouse for 1995 through 2000 are shown in Figure 4.2.7. Total uranium concentrations observed in 2000 were similar to those observed during recent years. Monthly total uranium concentrations measured at the Richland Pumpouse in 2000 were statistically higher than those measured at Priest Rapids Dam. Although there is no direct discharge of uranium to the river, uranium is present in the groundwater beneath the 300 Area as a result of past Hanford operations (see Section 7.1) and has been detected at elevated levels in riverbank springs in this area (see Section 4.2.3). Naturally occurring uranium is also known to enter the river across from the Hanford Site via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500). There are no ambient



surface-water quality criteria levels directly applicable to uranium. However, total uranium levels in the river during 2000 were well below the U.S. Environmental Protection Agency (EPA) drinking water standard of 30 $\mu\text{g/L}$ (~ 27 pCi/L, Appendix D, Table D.2).

The annual average iodine-129 concentrations at Priest Rapids Dam and Richland Pumphouse for 1995 through 2000 are presented in Figure 4.2.8. Only one quarterly iodine-129 result was available for the Richland Pumphouse during 1995 because of construction activities at the structure that interfered with sampling. The average iodine-129 concentration in Columbia River water at the Richland Pumphouse was extremely low during 2000 (0.012% of the ambient surface-water quality criteria level of 1 pCi/L [1 million aCi/L]) and similar to levels observed during recent years. The onsite source of iodine-129 to the Columbia River is the discharge of contaminated groundwater along the portion of shoreline downstream of the Old Hanford Townsite (see Section 7.1). The iodine-129 plume originated in the 200 Areas from past waste disposal practices.



Quarterly iodine-129 concentrations in Columbia River water at the Richland Pumphouse were statistically higher than those at Priest Rapids Dam.

Plutonium-239/240 concentrations were at or near the detection limits for filter (particulate) and resin (dissolved) components for all samples. Average plutonium-239/240 concentrations on filter samples at Priest Rapids Dam and Richland Pumphouse were 20 ± 6.7 and 14 ± 11 aCi/L, respectively. With the exception of one sample each at Priest Rapids Dam and the Richland Pumphouse, plutonium was only detected for the particulate fraction of the continuous water sample (i.e., detected on the filters but not detected on the resin column). No ambient surface-water quality criteria levels exist for plutonium-239/240. However, if the DOE derived concentration guides (see Appendix D, Table D.5), which are based on a 100-mrem dose standard, are converted to the 4-mrem dose equivalent used to develop the drinking water standards and ambient surface-water quality criteria levels, 1.2 million aCi/L





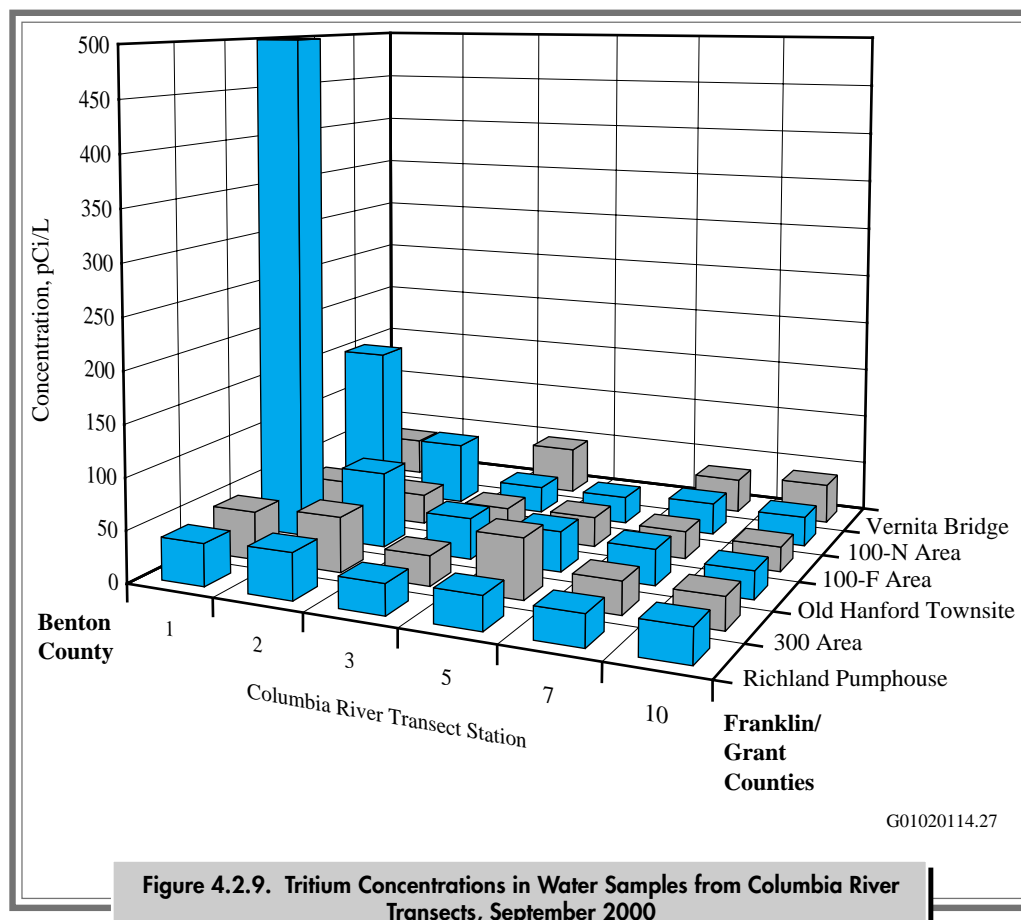
would be the relevant guideline for plutonium-239/240. There were no statistical differences in plutonium-239/240 concentrations for filter samples at Priest Rapids Dam and Richland Pump house. Statistical tests for dissolved plutonium concentrations at Priest Rapids Dam and the Richland Pump house were not performed because the majority of the concentrations were below the detection limit.

River Transect and Near-Shore Sampling.

Radiological results from samples collected along Columbia River transects and at near-shore locations near the Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pump house during 2000 are presented in Appendix B (Tables B.3 and B.4) and PNNL-13487, APP. 1. Sampling locations were documented using a global positioning system. Constituents consistently

detected at concentrations greater than two times their associated total propagated analytical uncertainty included tritium, strontium-90, uranium-234, and uranium-238. All measured concentrations of these radionuclides were less than applicable ambient surface-water quality criteria levels.

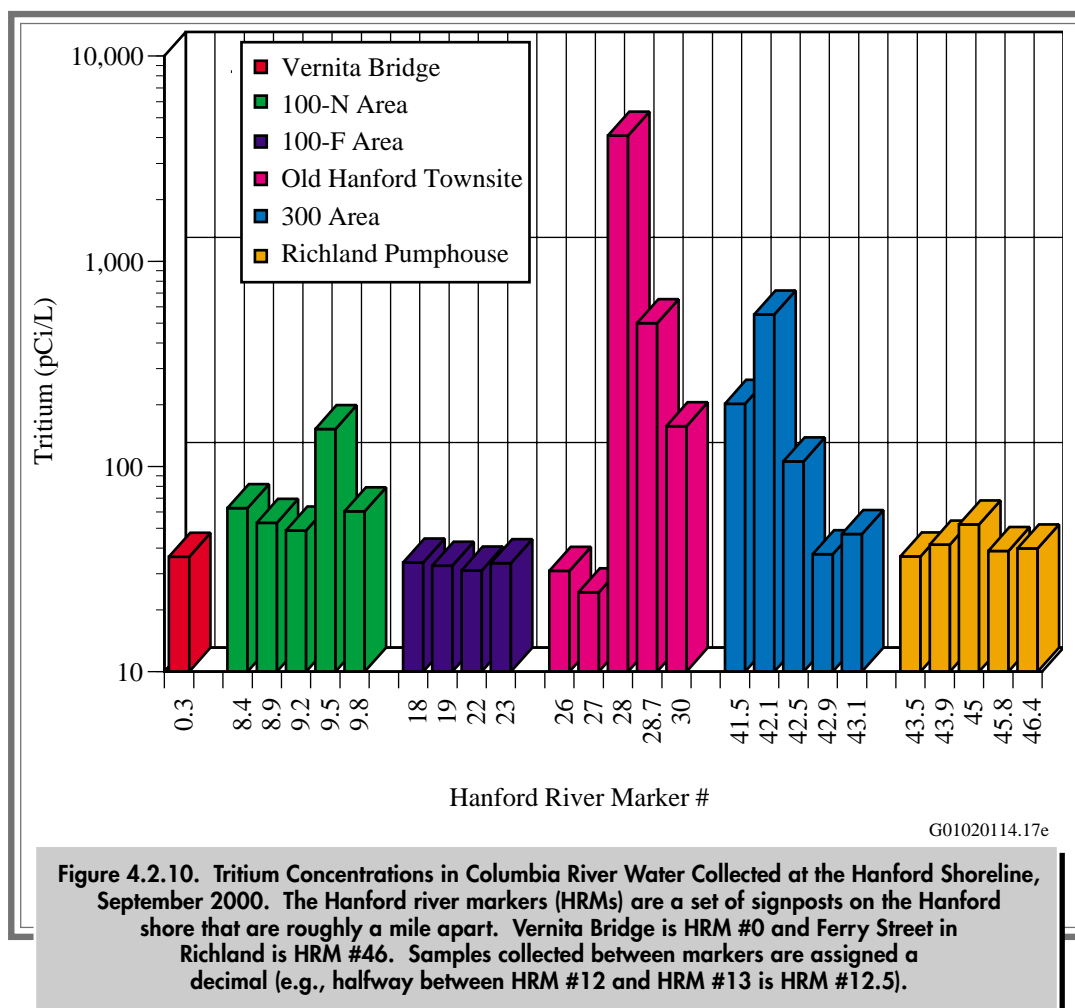
Tritium concentrations measured along Columbia River transects during September 2000 are depicted in Figure 4.2.9. The results are displayed such that the observer's view is upstream from the Richland Pump house. Vernita Bridge is the most upstream transect. Stations 1 and 10 are located along the Benton County and Franklin/Grant Counties shorelines, respectively. The 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pump house transects have higher tritium concentrations at the Hanford shore compared to the opposite



shore. The presence of a tritium concentration gradient in the Columbia River at the Richland Pumphouse supports previous conclusions made in HW-73672 and PNL-8531 that contaminants in the 200 Areas' groundwater plume entering the river at, and upstream of, the 300 Area are not completely mixed at the Richland Pumphouse. The gradient is most pronounced during periods of relatively low river flow. As noted since transect sampling was initiated in 1987, the mean tritium concentration measured along the Richland Pumphouse transect was less than that measured in monthly composited samples from the pumphouse, illustrating the conservative bias (i.e., overestimate) of the fixed-location monitoring station. The highest tritium concentration observed in 2000 for cross river transect water

samples was 500 ± 45 pCi/L (see Table B.3), which was detected along the shoreline of the Old Hanford Townsite. This is a location where groundwater containing tritium levels over 2,000 pCi/L is known to discharge to the river (see Section 7.1.6.1).

Tritium concentrations for near-shore water samples collected at the Hanford shoreline during September 2000 are shown in Figure 4.2.10. The near-shore sampling locations are identified according to Hanford River Markers, which are a series of signpost markers (~1.6 kilometers [1 mile] apart) that originate at Vernita Bridge (Hanford River Marker #0) and end just upriver from the Richland Pumphouse (Hanford River Marker #46). The concentrations of tritium in near-shore water samples





collected at the 100-N Area, Old Hanford Townsite, and 300 Area were elevated, compared to concentrations in samples collected near the Vernita Bridge. There was a wide range of tritium concentrations measured for the shoreline samples with the concentrations increasing near discharge points for the groundwater tritium plume (see Section 7.0, Figures 7.1.11, 7.1.12, and 7.1.19). The tritium concentrations in near-shore samples collected from the Richland shore were only slightly higher than those measured at Vernita Bridge. The highest tritium concentration observed in 2000 for near-shore water samples was $4,100 \pm 310$ pCi/L (see Appendix B, Table B.4), which was detected along the shoreline of the Old Hanford Townsite.

In 2000, strontium-90 concentrations in Hanford Reach river water for both transect and near-shore samples were similar to background concentrations for all locations, except for the 100-N Area. The 100-N Area had elevated strontium-90 concentrations in some samples obtained at near-shore locations and the near-shore location for the transect samples. The mean strontium-90 concentration found during transect sampling at the Richland Pumphouse was similar to that measured in monthly composite samples from the pumphouse; indicating that strontium-90 levels in water collected from the fixed-location monitoring station are representative of the average strontium-90 concentrations in the river at this location.

Total uranium concentrations in Hanford Reach water in 2000 were elevated along the Franklin County shoreline in both the 300 Area and Richland Pumphouse transects. The highest total uranium concentration was measured near the Franklin County shoreline of the Richland Pumphouse transect and likely resulted from groundwater seepage and water from irrigation return canals on the Franklin County side of the river that contained naturally occurring uranium (PNL-7500). The mean concentration of total uranium across the Richland Pumphouse transect was similar to that measured in monthly composited samples from the pumphouse.

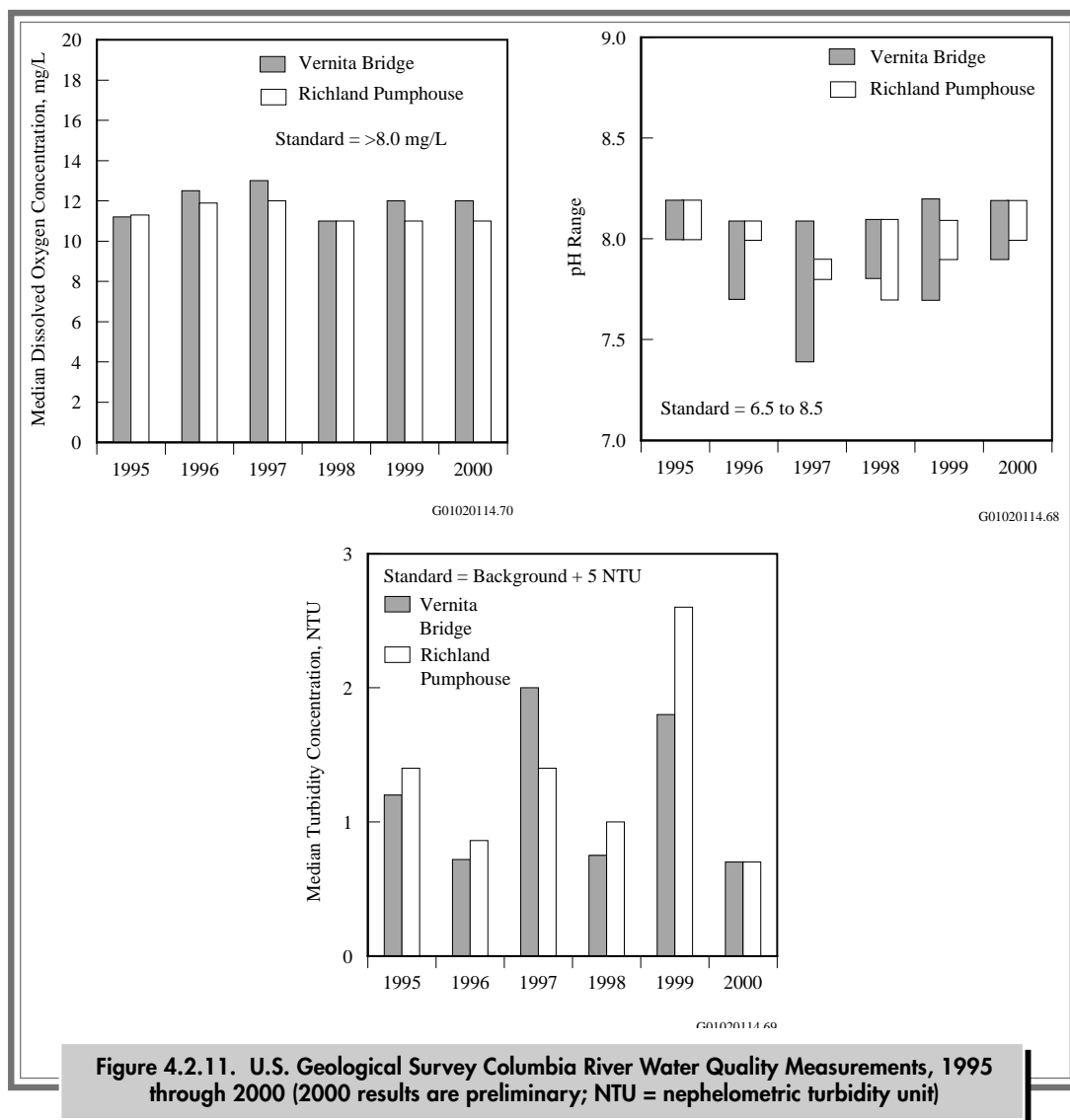
4.2.1.3 Chemical and Physical Results for River-Water Samples

The U.S. Geological Survey and the Pacific Northwest National Laboratory compiled chemical and physical water quality data during 2000. A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and contaminants of Hanford origin. Potential sources of pollutants not associated with Hanford include irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500).

U.S. Geological Survey. Figure 4.2.11 shows U.S. Geological Survey results for the Vernita Bridge and Richland Pumphouse for 1995 through 2000 (2000 results are preliminary) for several water quality parameters with respect to their applicable standards. The complete list of preliminary results obtained through the U.S. Geological Survey National Stream Quality Accounting Network program is documented in PNNL-13487, APP. 1 and is summarized in Appendix B (Table B.5). Final results are published annually by the U.S. Geological Survey (e.g., Zembrzusi et al. 1999). The 2000 U.S. Geological Survey results were comparable to those reported during the previous 5 years. Applicable standards for a Class A-designated surface-water body were met. During 2000, there was no indication of any deterioration of water quality resulting from site operations along the Hanford Reach of the Columbia River (see Appendix D, Table D.1).

River Transect and Near-Shore Samples.

Results of chemical sampling conducted by Pacific Northwest National Laboratory along transect and near-shore locations of the Columbia River in 2000 at Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse are provided in PNNL-13487, APP. 1. The concentrations of metals and anions observed in river water in 2000 were similar to those observed in the past. Several metals and anions were detected in



Columbia River transect samples both upstream and downstream of the Hanford Site. Arsenic, antimony, cadmium, chromium, lead, nickel, thallium, and zinc were detected in the majority of samples, with similar levels at most locations. Beryllium, selenium, and silver were only occasionally detected. Nitrate concentrations for water samples from the Benton County shoreline near the Richland Pumphouse were similar to mid-river samples. Nitrate, sulfate, and chloride concentrations were slightly elevated, compared to mid-river samples, along the Franklin County shoreline at the Richland Pumphouse transects and likely resulted from groundwater seepage associated with

extensive irrigation north and east of the Columbia River. Nitrate contamination of some Franklin County groundwater has been documented by the U.S. Geological Survey (1995) and is associated with high fertilizer and water usage in agricultural areas. Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate (40 CFR 141; USGSCircular 1144). Average nitrate, sulfate, and chloride results were slightly higher for average quarterly concentrations at the Richland Pumphouse transect compared to the Vernita Bridge transect. Nitrate, chloride, and sulfate concentrations were slightly elevated, compared to mid-river,





for both shorelines at the 300 Area. There were no apparent concentration gradients for anions measured in transect samples collected at Vernita Bridge, 100-N Area, 100-F Area, and Old Hanford Townsite.

Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; see Appendix D, Table D.3). Criteria for Columbia River water were calculated using a total hardness of 47 mg/L as calcium carbonate, the limiting value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge and the

Richland Pumphouse over the past 7 years. The total hardness reported by the U.S. Geological Survey at those locations from 1992 through 2000 ranged from 47 to 77 mg/L as calcium carbonate. All metal and anion concentrations in river water were less than the ambient surface-water quality criteria levels for the protection of aquatic life from both acute and chronic toxicity levels (see Appendix B, Table B.6 and Appendix D, Table D.3). Arsenic concentrations exceeded EPA standards; however, similar concentrations were found at Vernita Bridge and the Richland Pumphouse (see Appendix D, Table D.3).

4.2.2 Columbia River Sediment

Upon release to the Columbia River, radioactive and non-radioactive materials were dispersed rapidly, sorbed onto detritus and inorganic particles, incorporated into aquatic biota, deposited on the riverbed as sediment, or flushed out to sea. The concentrations of the radioactive material decreased as it underwent radioactive decay. Fluctuations in the river flow rate, as a result of the operation of hydroelectric dams, annual spring freshets, and occasional floods, have resulted in the resuspension, relocation, and subsequent redeposition of the sediment (DOE/RL-91-50). Sediment in the Columbia River contains low concentrations of radionuclides and metals of Hanford Site origin as well as radionuclides from nuclear weapons testing fallout (Beasley et al. 1981, BNWL-2305, PNL-8148, PNL-10535). Potential public exposures are well below the level at which routine surveillance of Columbia River sediment is required (PNL-3127, Wells 1994). However, periodic sampling is necessary to confirm the low levels and to ensure that no significant changes have occurred for this pathway. The accumulation of radioactive materials in sediment can lead to human exposure by ingestion of aquatic organisms, sediment resuspension into drinking water supplies, or as an external radiation source irradiating people who are fishing,

wading, sunbathing, or participating in other recreational activities associated with the river or shoreline (DOE/EH-0173T).

Since the shutdown of the last single-pass reactor in the early 1970s, the contaminant burden in the surface sediment has been decreasing as a result of radioactive decay and the subsequent deposition of uncontaminated material. However, discharges of some pollutants from the Hanford Site to the Columbia River still occur via permit-regulated liquid effluent discharges (see Section 3.1) and via contaminated groundwater seepage (see Section 4.2.3).

A special study was conducted in 1994 to investigate the difference in sediment grain-size composition and total organic carbon content at routine monitoring sites (PNL-10535). Physical and chemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were collected above McNary Dam and from White Bluffs Slough. All other samples primarily consisted of sand. Higher contaminant burdens were generally associated with sediment containing higher total organic carbon and finer grain-size distributions.

4.2.2.1 Collection of Sediment Samples and Analytes of Interest

During 2000, samples of Columbia River surface sediment were collected at depths of 0 to 15 centimeters (0 to 6 inches) from six river locations that are permanently submerged and six riverbank springs that are periodically inundated (see Figure 4.2.1 and Table 4.2.2). Sediment sampling locations were documented using a global positioning system. Samples were collected upstream of Hanford Site facilities above Priest Rapids Dam (the nearest upstream impoundment) to provide background data from an area unaffected by site operations. Samples were collected downstream of the Hanford Site above McNary Dam (the nearest downstream impoundment) to identify any increase in contaminant concentrations. Note that any increases in contaminant concentrations found in sediment above McNary Dam relative to that found above Priest Rapids Dam do not necessarily reflect a Hanford Site source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns, irrigation water returns, and factories in these drainages may also contribute to the contaminant load found in McNary Dam sediment; thus, sediment samples were taken at Ice Harbor Dam in 1998 and 1999 to assess Snake River inputs. Sediment samples were also collected along the Hanford Reach of the Columbia River from areas close to contaminant discharges (e.g., riverbank springs), from slackwater areas where fine-grained material is known to deposit (e.g., the White Bluffs, 100-F Area, and Hanford Sloughs), and from the publicly accessible Richland shoreline.

Monitoring sites at McNary and Priest Rapids Dams consisted of two stations spaced equidistant (approximately) on a transect line crossing the Columbia River; the samples were collected near the boat exclusion buoys at each dam. All other monitoring sites consisted of a single sampling location.

Samples of permanently inundated river sediment were collected using a clam-shell style sediment dredge. Samples of periodically inundated river sediment, (riverbank springs sediment) were collected using a large plastic spoon, immediately following the collection of riverbank springs water samples. Sampling methods are discussed in detail in DOE/RL-91-50. All sediment samples were analyzed for gamma emitting radionuclides (see Appendix F), strontium-90, uranium-235, uranium-238, and metals (DOE/RL-91-50). Selected river sediment samples were also analyzed for plutonium-238, plutonium-239/240, metals, and simultaneously extracted metals/acid volatile sulfide (SEM/AVS) (PNNL-13417). The specific analytes selected for Columbia River sediment samples were based on findings of previous Columbia River sediment investigations, reviews of past and present effluents discharged from site facilities, and reviews of contaminant concentrations observed in near-shore groundwater monitoring wells.

4.2.2.2 Radiological Results for Samples from River Sediment

Results of the radiological analyses on river sediment samples collected during 2000 are reported in PNNL-13487, APP. 1 and summarized in Appendix B (Table B.7). Radionuclides consistently detected in river sediment adjacent and downstream of the Hanford Site during 2000 included potassium-40, cesium-137, uranium-238, plutonium-238, and plutonium-239/240. The concentrations of all other radionuclides were below detection limits for most samples. Cesium-137 and plutonium isotopes exist in worldwide fallout, as well as in effluents from Hanford Site facilities. Uranium occurs naturally in the environment in addition to being present in Hanford Site effluents. Comparisons of contaminant levels between sediment sampling locations are made below. Because of variations in the bioavailability of contaminants in various sediment, no federal or state freshwater sediment criteria are





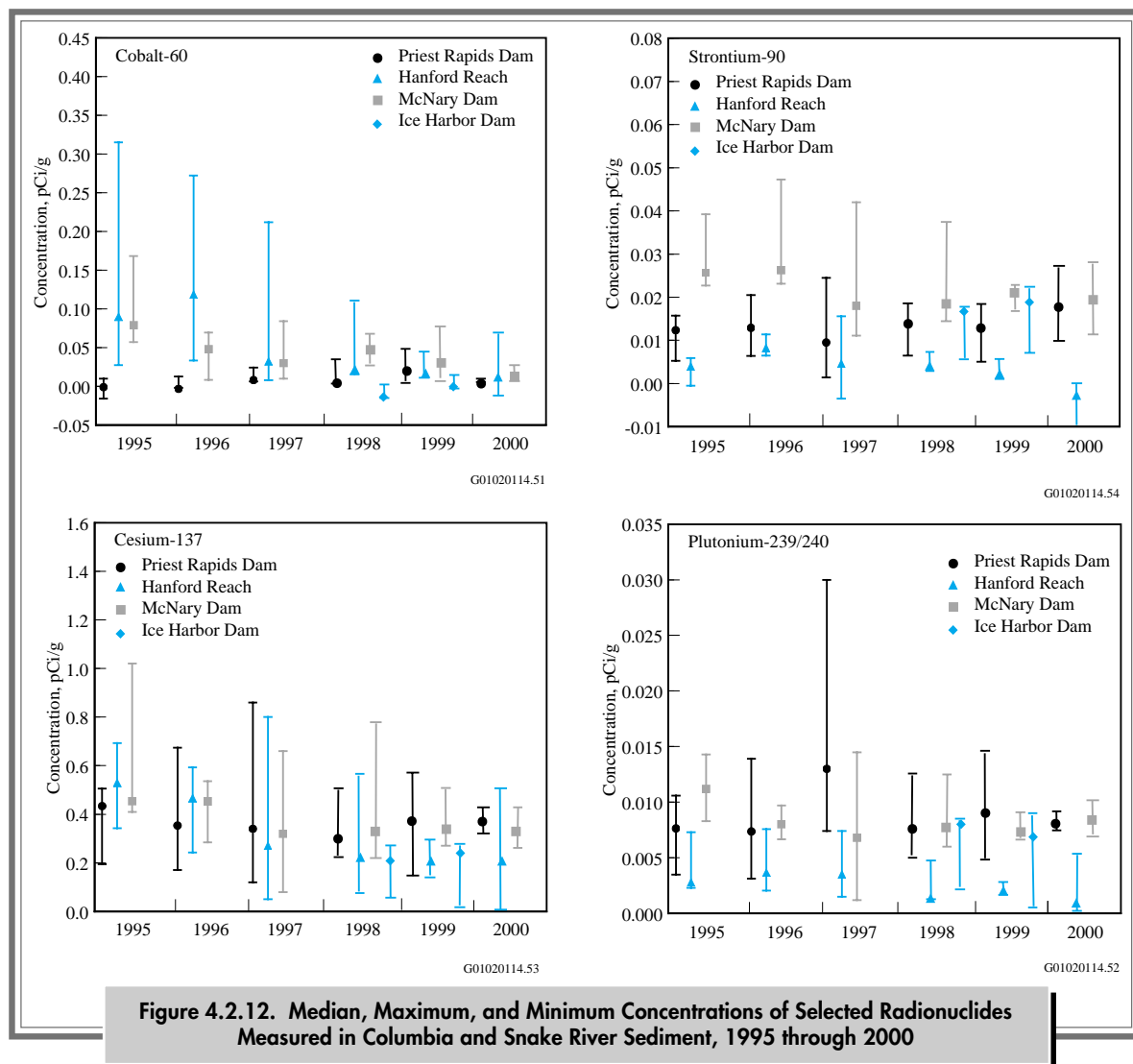
available to assess the sediment quality of the Columbia River (EPA 822-R-96-001).

Radionuclide concentrations reported in river sediment in 2000 were similar to those reported for previous years (see Appendix B, Table B.7). Median, maximum, and minimum concentrations of selected radionuclides measured in Columbia (1995 through 2000) and Snake River sediment from 1995 through 2000 are presented in Figure 4.2.12. Sampling areas include stations at Priest Rapids, McNary, and Ice Harbor Dams as well as the Hanford Reach stations (White Bluffs, 100-F Area and Hanford Sloughs, and the Richland Pumpouse). Strontium-90 was the

only radionuclide to exhibit consistently higher median concentrations at McNary Dam from 1995 through 2000; however, many of the recent values were below the detection limit. No other radionuclides measured in 2000 exhibited appreciable differences in concentrations between locations.

4.2.2.3 Radiological Results for Sediment Samples from Riverbank Springs

Sampling of sediment from riverbank springs was begun in 1993 at the Old Hanford Townsite and

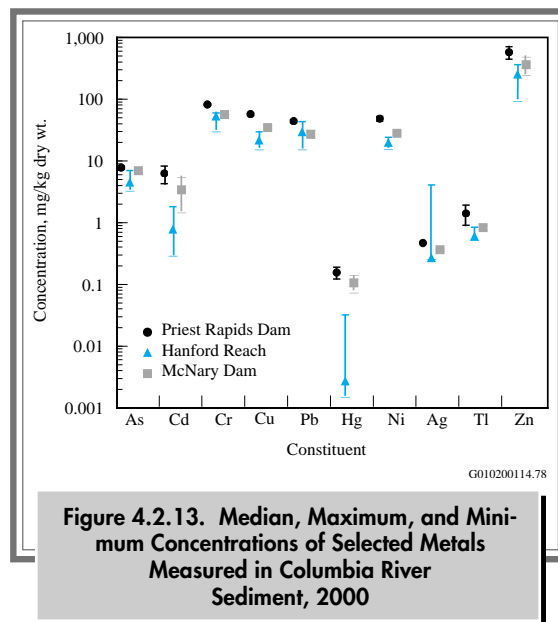


300 Area. Sampling of the riverbank springs in the 100-B, 100-F, and 100-K Areas was initiated in 1995. Substrates at all other riverbank springs sampling locations consist of predominantly large cobble and are unsuitable for sample collection.

Radiological results for sediment collected from riverbank springs in 2000 are presented in PNNL-13487, APP. 1 and are summarized in Appendix B (Table B.7). Results were similar to those observed for previous years. In 2000, sediment samples were collected at riverbank springs in the 100-B Area, 100-F Area, Old Hanford Townsite, and 300 Area. There were no sediment available for sampling at the 100-K and 100-N Area locations. In 2000, radionuclide concentrations in riverbank spring sediment were similar to those observed in river sediment.

4.2.2.4 Chemical Results for Sediment Samples from the Columbia River and from Riverbank Springs

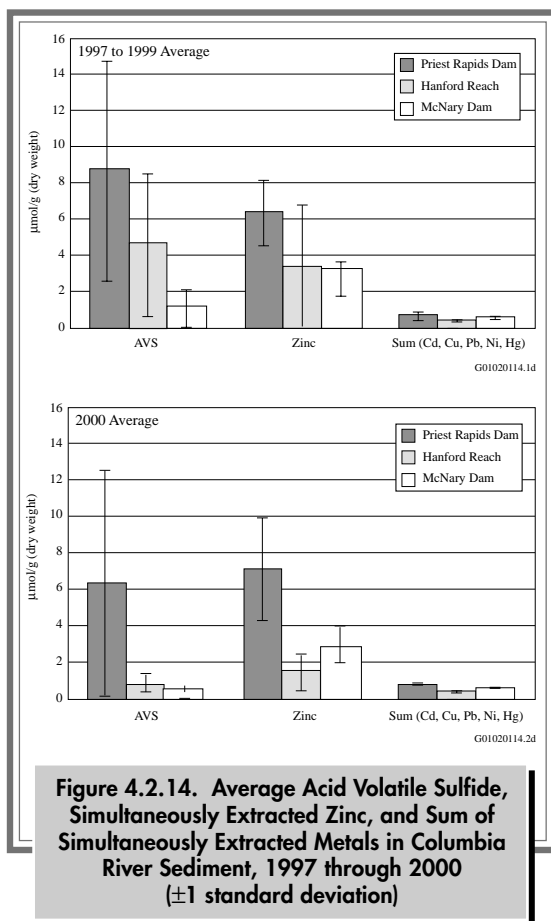
Metal concentrations (total metals, reported on a dry weight basis) observed in Columbia River sediment in 2000 are reported in PNNL-13487, APP. 1 and are summarized in Appendix B (Table B.8). Detectable amounts of most metals were found in all river sediment samples (Figure 4.2.13). Maximum and median concentrations of most metals were higher for sediment collected at Priest Rapids Dam compared to either Hanford Reach or McNary Dam sediment. The concentrations of cadmium, chromium, lead, nickel, thallium, and zinc had the largest differences between locations. In general, the metals concentrations in Hanford Reach sediment were more similar to McNary Dam sediment than Priest Rapids Dam sediment. Metal concentrations in riverbank spring sediment samples in 2000 were similar to concentrations in Hanford Reach sediment samples. Currently, there are no Washington State freshwater sediment quality criteria for comparison to the measured values.



From 1997 to 2000, Columbia River sediment also was analyzed for SEM/AVS. This analysis involved a cold acid extraction of the sediment followed by analysis for sulfide and metals. The SEM/AVS ratios are an indicator of potential sediment toxicity (DeWitt et al. 1996; Hansen et al. 1996). Acid volatile sulfide is an important binding phase for divalent metals (i.e., metals with a valence state of 2+, such as Pb^{2+}) in sediment. Metal sulfide precipitates are typically very insoluble, and this limits the amount of dissolved metal available in the sediment porewater. For an individual metal, when the amount of acid volatile sulfide exceeds the amount of the metal (i.e., the SEM/AVS molar ratio is below 1), the metal concentration in the sediment porewater will be low because of the limited solubility of the metal sulfide. For a suite of divalent metals, the sum of the simultaneously extracted metals must be considered, with the assumption that the metal with the lowest solubility will be the first to combine with the acid volatile sulfide.

The SEM/AVS results for the 2000 samples were similar to previous years (Figure 4.2.14), with the exception of the average AVS concentration in the Hanford Reach, which was lower (PNNL-13417).





For 2000, the acid volatile sulfide values in sediment from the Priest Rapid Dam reservoir had concentrations ranging from 2.0 to 11 $\mu\text{mol/g}$. Sediment from the Hanford Reach and McNary Dam reservoir had lower concentrations of acid volatile sulfide, with values ranging from 0.50 to 1.7 $\mu\text{mol/g}$. For 2000, the SEM/AVS molar ratios were near one for Priest Rapids Dam. For 2000, SEM/AVS molar ratios for sediment from the Hanford Reach and McNary Dam were above one, indicating a potential for some metals to be present in the sediment porewater. For all locations, zinc was the primary SEM metal present.

These results reveal an apparent difference in the acid volatile sulfide concentrations in sediment from Priest Rapids Dam reservoir, which had higher concentrations than Hanford Reach and McNary Dam. An apportionment of acid volatile sulfide by divalent metals according to solubility values revealed that sufficient acid volatile sulfide should exist in all locations to limit the porewater concentrations of cadmium, copper, lead, and mercury. For Priest Rapids Dam sediment, average zinc values were of similar magnitude as the average acid volatile sulfide concentrations. For Hanford Reach and McNary Dam sediment, the average zinc concentrations were higher than the available mean acid volatile sulfide pool, indicating the potential for zinc and possibly other metals to be available for biological uptake in the sediment porewater.

4.2.3 Riverbank Spring Water

The Columbia River is the primary discharge area for the unconfined aquifer underlying the Hanford Site (see Section 7.1.2). Groundwater provides a means for transporting Hanford-associated contaminants, which have leached into groundwater from past waste disposal practices, to the Columbia River (DOE/RL-92-12; PNL-5289; PNL-7500; WHC-SD-EN-TI-006). Contaminated groundwater enters the Columbia River via surface and subsurface discharge. Discharge zones located above the water level

of the river are identified in this report as riverbank springs. Routine monitoring of riverbank springs offers the opportunity to characterize the quality of groundwater being discharged to the river and to assess the potential human and ecological risk associated with the spring water.

The seepage of groundwater into the Columbia River has occurred for many years. Riverbank springs were documented along the Hanford Reach long before Hanford Site operations began during World

War II (Jenkins 1922). In the early 1980s, researchers walked the 66-kilometer (41-mile) stretch of Benton County shoreline of the Hanford Reach and identified 115 springs (PNL-5289). They reported that the predominant areas of groundwater discharge at that time were in the vicinity of the 100-N Area, Old Hanford Townsite, and 300 Area. The predominance of the 100-N Area may no longer be valid because of declining water-table elevations in response to the cessation of in liquid waste discharges to the ground from Hanford Site operations. In recent years, it has become increasingly difficult to locate riverbank springs in the 100-N Area.

The presence of riverbank springs also varies with river stage. Groundwater levels in the 100 and 300 Areas are heavily influenced by river stage fluctuations (see Section 7.1). Water levels in the Columbia River fluctuate greatly on annual and even daily cycles and are controlled by the operation of Priest Rapids Dam upstream of the site. Water flows into the aquifer (as bank storage) as the river stage rises and flows in the opposite direction as the river stage falls. Following an extended period of low river flow, groundwater discharge zones located above the water level of the river may cease to exist once the level of the groundwater comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in river stage. Bank storage of river water also affects the contaminant concentration of the springs. Spring water discharge immediately following a river stage decline generally consists of river water or a river/groundwater mix. The percentage of groundwater in the spring water discharge is believed to increase over time following a drop in river stage. Measuring the specific conductivity of the spring water discharge provides an indicator of the extent of bank storage because the Hanford Site groundwater has higher specific conductivity than the Columbia River.

Because of the effect of bank storage on groundwater discharge and contaminant concentration, it

is difficult to estimate the volume of contaminated groundwater discharged to the Columbia River within the Hanford Reach. The estimated total groundwater discharge from the upstream end of the 100 Areas to south of the 300 Area is $\sim 66,500 \text{ m}^3$ ($2.35 \text{ million ft}^3$) per day.^(a) This represents only 0.02% of the long-term average flow rate of the Columbia River, which illustrates the tremendous dilution potential afforded by the river. It should be noted that not all of the groundwater discharged to the river contains contaminants originating from Hanford Site operations. Studies of riverbank springs conducted in 1983 (PNL-5289) and in 1988 (PNL-7500) and a near-shore study (PNNL-11933) noted that discharges from the springs had a localized effect on river contaminant concentrations. Both studies reported that the volume of groundwater entering the river at these locations was very small compared to the flow of the river and that the impact of groundwater discharges to the river was minimal.

4.2.3.1 Collection of Water Samples from Riverbank Springs and Analytes of Interest

Routine monitoring of selected riverbank springs was initiated in 1988. Currently, riverbank spring water samples are collected for environmental surveillance and to support groundwater operable unit investigations. The locations of all riverbank springs sampled in 2000 are identified in Figure 4.2.1. Sample collection methods are described in DOE/RL-91-50. Analytes of interest for samples from riverbank springs were selected based on findings of previous investigations, reviews of contaminant concentrations observed in nearby groundwater monitoring wells, and results of preliminary risk assessments. Sampling is conducted annually when river flows are low, typically in late summer/fall.

(a) Personal communication from S. P. Luttrell to G. W. Patton, Pacific Northwest National Laboratory, Richland, Washington, January 1995.





Samples of water from riverbank springs were collected from September to November 2000. All samples collected during 2000 were analyzed for gamma-emitting radionuclides, gross alpha, gross beta, and tritium. Samples from selected springs were analyzed for strontium-90, technetium-99, iodine-129, and uranium-234, -235, and -238. All samples were analyzed for metals and anions, with volatile organic compounds analyzed at selected locations. All analyses were conducted on unfiltered samples, except for metals analyses, which were conducted for both filtered and unfiltered samples.

Hanford-origin contaminants continued to be detected in water from riverbank springs entering the Columbia River along the Hanford Site during 2000. The locations and extent of contaminated discharges were consistent with recent groundwater surveys. Tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, and -238, metals, and anions (chloride, fluoride, nitrate, and sulfate) were detected in spring water. Volatile organic compounds were near or below the detection limits for most samples. The contaminant concentrations in water from riverbank springs are typically lower than those found in near-shore groundwater wells because of bank storage effects.

Results of radiological and chemical analyses conducted on samples from riverbank springs in 2000 are documented in PNNL-13487, APP. 1. Radiological results obtained in 2000 are summarized in Appendix B (Table B.9) and compared to those reported in 1995 through 1999. In the following discussion, radiological and chemical results are addressed separately. Contaminant concentration trends are illustrated for selected locations.

4.2.3.2 Radiological Results for Water Samples from Riverbank Springs

All radiological contaminant concentrations measured in riverbank springs in 2000 were less than the DOE derived concentration guides (DOE Order

5400.5; see Appendix D, Table D.5). However, the spring at the 100-N Area that has historically exceeded the DOE derived concentration guide for strontium-90 only had observed flow during one (1997) sampling attempt in the last 6 years; thus, an alternative spring was sampled in the 100-N Area. Tritium concentrations in water samples collected in 2000 from riverbank springs at the Old Hanford Townsite exceeded the ambient surface-water quality criteria levels (WAC 173-201A and 40 CFR 141). The tritium concentration in riverbank spring water collected in 2000 at 100-N was 90% of the ambient surface water criteria level (WAC 173-201A and 40 CFR 141), with tritium levels near 50% of the criteria at the 100-D and 300 Area locations. The strontium-90 concentration in riverbank spring water was greater than 50% of the criteria level at the 100-H Area location. There are no ambient surface-water quality criteria levels directly applicable to uranium. However, total uranium concentrations exceeded the EPA drinking water standard (EPA 822-R-96-001) in the 300 Area (see Appendix D, Table D.2). The gross alpha concentration exceeded the ambient surface-water quality criteria level (15 pCi/L, Appendix D, Table D.2) in riverbank spring water at the 300 Area, which is consistent with the elevated uranium levels. All other radionuclide concentrations in 300 Area springs water were less than ambient surface-water quality criteria levels. Gross beta concentrations in riverbank spring water at the Old Hanford Townsite and the 300 Area (22 to 30 pCi/L) were elevated compared to other riverbank spring water locations.

Tritium concentrations varied widely with location. The highest tritium concentration detected in riverbank springs water was at the Old Hanford Townsite ($79,000 \pm 3,100$ pCi/L), followed by the 100-N Area ($18,000 \pm 800$ pCi/L), 300 Area ($9,900 \pm 510$ pCi/L), and 100-D Area ($9,800 \pm 730$ pCi/L). The ambient surface-water quality criteria level for tritium is 20,000 pCi/L. Tritium concentrations in all riverbank springs water samples were elevated compared to the 2000 average Columbia River concentration at Priest Rapids Dam (35 ± 5.6 pCi/L).

Samples from riverbank springs in the 100-B, 100-H, 100-K, and 300 Areas and the Old Hanford Townsite were analyzed for technetium-99. All results were below the EPA drinking water standard (see Appendix D, Table D.2). The highest technetium-99 concentration was found in riverbank spring water from the Old Hanford Townsite (80 ± 6.1 pCi/L), in agreement with the observed gross beta concentrations (30 ± 4.9 pCi/L).

Samples from riverbank springs at the Old Hanford Townsite and 300 Area were analyzed for iodine-129. The highest concentration was measured in a water sample from the Old Hanford Townsite spring (0.27 ± 0.029 pCi/L). This value was elevated compared to the 2000 average measured at Priest Rapids Dam (0.0000082 ± 0.0000050 pCi/L) but was below the 1-pCi/L surface-water quality criteria level (see Appendix D, Table D.2).

Uranium was sampled in riverbank spring water in the 100-H Area, 100-F Area, Old Hanford Townsite, and 300 Area in 2000. The highest level was found in 300 Area spring water (130 ± 27 pCi/L), which was collected from a spring located down-gradient from the retired 300 Area process trenches. The 300 Area spring had elevated gross alpha concentration (120 ± 29 pCi/L), which paralleled that of uranium.

Samples from riverbank springs were analyzed for strontium-90 in the 100-B, 100-D, 100-F, 100-H, 100-K, and 100-N Areas. The highest strontium-90 concentration detected in riverbank spring water was at the 100-H Area (5.6 ± 1.3 pCi/L). This value was below the ambient surface water quality criteria of 8 pCi/L.

Historically, riverbank seepage in the 100-N Area has been monitored for contaminants by sampling from well 199-N-8T, which is located close to the river; well 199-N-46 (caisson), which is slightly inland from well 199-N-8T (PNNL-11795, Figure 3.2.4); or riverbank springs. Since 1993, 100-N Area seepage samples for the Surface

Environmental Surveillance Project have been collected only from riverbank springs. The Near-Facility Environmental Monitoring program (see Section 3.2.2) also collects water samples along the 100-N shoreline at monitoring well 199-N-46 and at shoreline seepage wells. The Near-Facility Environmental Monitoring program reported all strontium-90 concentrations in calendar year 2000 samples were below the 1,000 pCi/L derived concentration guide for shoreline seepage wells near monitoring well 199-N-46 (see Table 3.2.4). For 1993 to 2000, there were no visible riverbank springs directly adjacent to wells 199-N-8T or 199-N-46 during the Surface Environmental Surveillance Project sampling periods; with the exception of one sample collected in 1997. The 100-N Area riverbank springs samples were, therefore, collected from a downstream riverbank spring. Contaminant activities measured in the water from the two riverbank springs locations sampled in previous years were distinctly different from each other (Table 4.2.3). Historically, the concentrations of strontium-90 and gross beta were considerably higher in the riverbank

Table 4.2.3. Selected Radionuclide Concentrations in 100-N Area Riverbank Spring Water, 1995 through 2000

Year	Concentration, pCi/L ^(a)		
	Tritium	Gross Beta	Strontium-90
1995 ^(b)	12,000 \pm 970	1.5 \pm 1.5	0.079 \pm 0.10
1996 ^(b)	17,000 \pm 1,300	4.5 \pm 1.8	0.053 \pm 0.048
1997 ^(b)	19,000 \pm 1,500	3.5 \pm 1.6	0.59 \pm 0.13
1997 ^(c)	14,000 \pm 1,100	16,000 \pm 1,400	9,900 \pm 1,800
1998 ^(b)	24,000 \pm 1,900	2.3 \pm 2.1	^(d)
1999 ^(b)	14,000 \pm 670	2.9 \pm 1.7	0.026 \pm 0.034
2000 ^(b)	18,000 \pm 800	5.9 \pm 2.1	-0.0026 \pm 0.037

(a) Concentrations are ± 2 total propagated analytical uncertainty.

(b) Sample collected from riverbank spring downstream of well 199-N-8T.

(c) Samples collected from spring below well 199-N-8T (100-N Area spring 8-13, see PNNL-11795, Figure 3.2.4).

(d) Sample was lost during processing at the analytical laboratory.

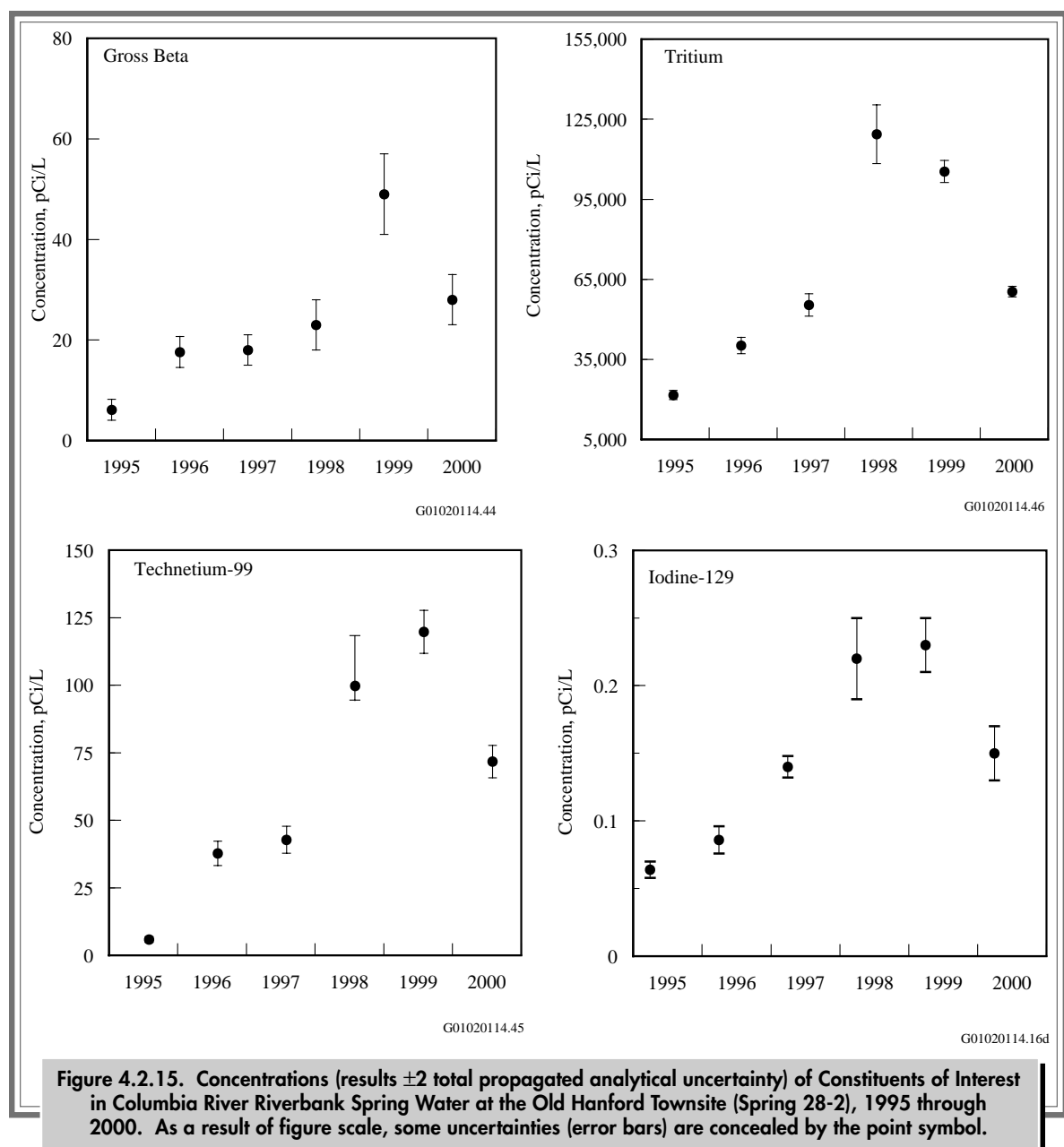




spring directly adjacent to well 199-N-8T than for the downstream spring. Tritium levels in water from riverbank springs are typically elevated at both locations, and the 2000 tritium result for the 100-N riverbank spring was similar to those found in previous years (see Table 4.2.3). Tritium was the only specific radionuclide detected at the 100-N Area riverbank spring in 2000. The tritium concentration was 90% of the ambient surface-water quality

criteria level (see Appendix D, Table D.2). The tritium concentration for the samples from 100-N Area riverbank spring was more than 13 times higher than the maximum value reported in Section 3.2, Table 3.2.4.

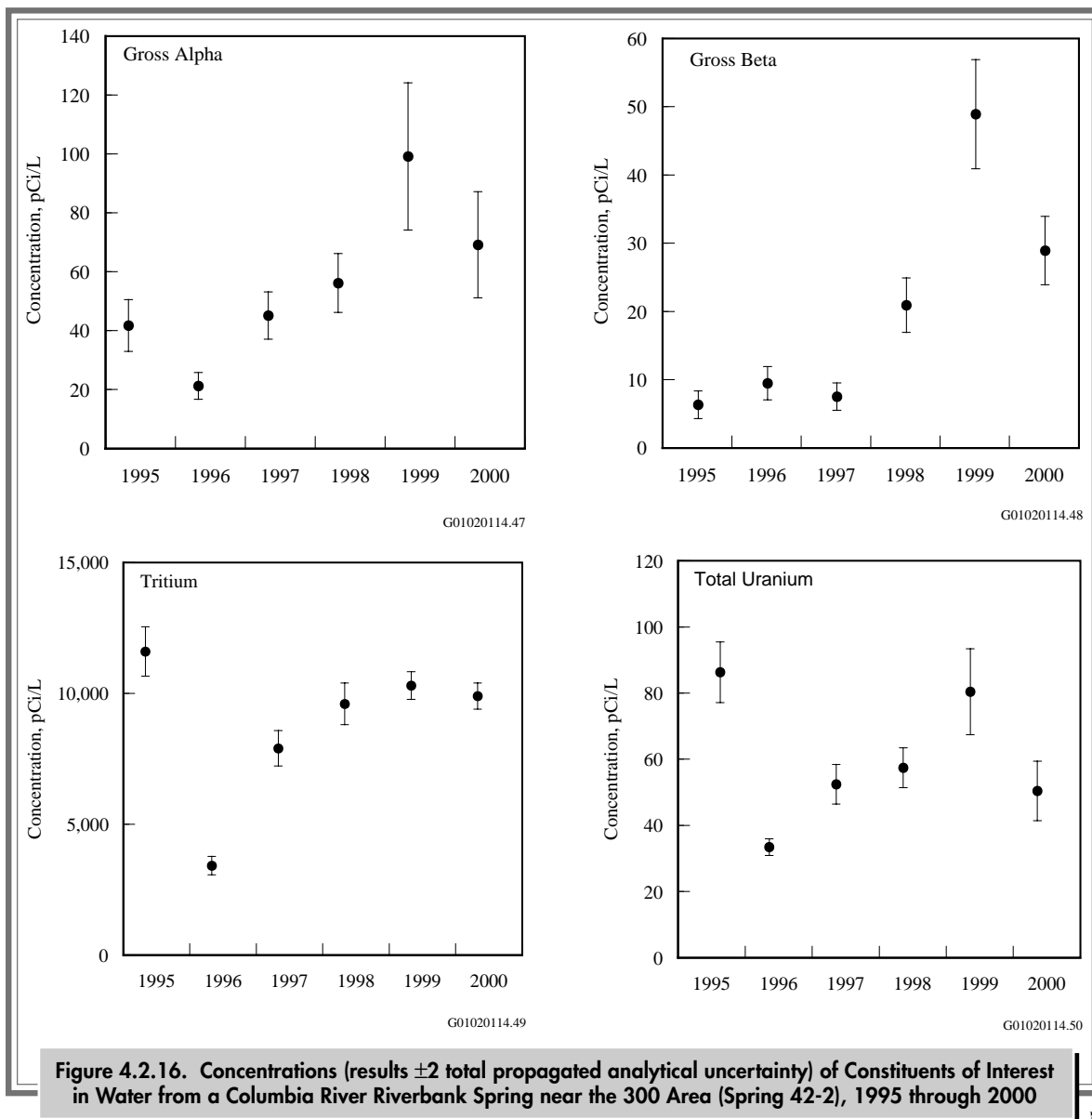
Concentrations of selected radionuclides in riverbank spring water near the Old Hanford Townsite (spring 28-2) from 1995 through 2000 are provided in Figure 4.2.15. Several of the radionuclides



show what appear to be increasing trends since 1995; however, radionuclide concentrations measured in the early 1990s were similar to the 2000 concentrations (see Figure 4.2.13 in PNNL-11472). Annual fluctuations in these values may reflect the influence of bank storage during the sampling period. The maximum tritium and technetium-99 levels detected in water from Old Hanford Townsite riverbank springs in 2000 were 395% and 93% of their respective ambient surface-water quality criteria levels (see Appendix D, Table D.2). The maximum iodine-129

concentration measured in water from the Old Hanford Townsite riverbank springs for 2000 was 27% of the ambient surface-water quality criteria level (see Appendix D, Table D.2).

Figure 4.2.16 depicts the concentrations of selected radionuclides in the 300 Area riverbank spring (spring 42-2) from 1995 through 2000. Results in 2000 were similar to those observed previously. The elevated tritium levels measured in the 300 Area riverbank springs are indicators of the





contaminated groundwater plume from the 200 Areas (Section 5.9 in PNL-10698). In addition, iodine-129 is also contained in the 200 Areas' contaminated groundwater plume. The maximum tritium and iodine-129 concentrations in water from the 300 Area riverbank springs in 2000 were 50% and 0.57% of their respective ambient surface-water quality criteria levels (see Appendix D, Table D.2). The highest total uranium levels in riverbank spring water from 1995 through 2000 were found in the 300 Area riverbank springs. The 2000 maximum total uranium value was nearly 5 times higher than the EPA drinking water standard (30 $\mu\text{g/L}$ or ~ 27 pCi/L; see Appendix D, Table D.2). Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area in the vicinity of uranium fuel fabrication facilities and inactive waste sites. The gross alpha and gross beta concentrations in the 300 Area riverbank springs water from 1995 through 2000 parallel uranium and are likely associated with its presence.

4.2.3.3 Chemical Results for Water Samples from Riverbank Springs

Concentration ranges of selected chemicals measured in riverbank springs water in 1999 through 2000 are presented in Table 4.2.4. For most locations, the 2000 non-radiological sample results were similar to

those reported previously (PNNL-12088). Nitrate concentrations were highest in the 100-F and 100-H Areas. Chromium concentrations were highest in the 100-B, 100-D, 100-H, and 100-K Areas' riverbank springs. Hanford groundwater monitoring results for 2000 indicated similar non-radiological contaminants in shoreline areas (see Section 7.1).

The ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; see Appendix D, Table D.3). For comparison purposes, spring water criteria were calculated using the same 47-mg calcium carbonate per liter hardness given in Appendix D, Table D.3. Most metal concentrations measured in water from riverbank springs collected from the Hanford Site shoreline in 1999 through 2000 were below ambient surface-water acute toxicity levels (WAC 173-201A). However, concentrations of chromium in 100-B, 100-K, 100-N, 100-D, 100-H, and 100-F, and 300 Areas spring water were above ambient surface water acute toxicity levels (see Appendix D, Table D.3). Arsenic concentrations in riverbank spring water were well below ambient surface water chronic toxicity levels, but all samples (including upriver Columbia River water samples) exceeded the federal limit (40 CFR 141; see Appendix D, Table D.3). Nitrate concentrations at all spring water locations were below the drinking water standard (see Appendix D, Table D.2).

4.2.4 Onsite Pond Water

Two onsite ponds (see Figure 4.2.1), located near operational areas, were sampled periodically during 2000. The ponds are inaccessible to the public and, therefore, did not constitute a direct offsite environmental impact during 2000. However, they were accessible to migratory waterfowl, creating a potential biological pathway for the dispersion of contaminants (PNL-10174). The Fast Flux Test Facility pond

is a disposal site for process water (primarily cooling water drawn from groundwater wells). West Lake, the only naturally occurring pond on the site, is located north of the 200-East Area (ARH-CD-775). West Lake has not received direct effluent discharges from Hanford Site facilities but is influenced by changing water-table elevation as a result of previous discharge of water to the ground in the 200 Areas.

Table 4.2.4. Concentration Ranges for Selected Chemicals in Water from Columbia River Springs, 1999 through 2000

Ambient Water Quality Criteria Level ^(a)		Concentration, µg/L						Old Hanford	
		100-B Area	100-K Area	100-N Area	100-D Area	100-H Area	100-F Area	Townsite	300 Area
No. of Samples		3	3	2	4	4	2	6	4
Dissolved Metals (µg/L)									
Antimony	NA	0.14 - 0.19	0.15 - 0.22	0.22	0.18 - 0.21	0.23 - 0.28	0.12 - 0.2	0.13 - 0.39	0.20 - 0.36
Arsenic	190	0.93 - 1.6	0.32 - 1.6	2.2 - 2.9	0.66 - 0.94	0.58 - 2.0	1.5 - 2.4	2.6 - 4.8	0.95 - 1.6
Cadmium	0.59	0.010 - 0.012	0.0044 - 0.010	0.011 - 0.031	0.017 - 0.041	0.0044 - 0.034	0.0091 - 0.021	0.020 - 0.051	0.017 - 0.078
Chromium ^(b)	10	9.8 - 20	2.1 - 49	7.7 - 11	24 - 150	4.0 - 17	14 - 22	1.8 - 4.6	2.6 - 3.7
Copper	6	0.27 - 2.1	0.38 - 0.46	0.25 - 0.28	0.38 - 0.57	0.41 - 5.6	0.37 - 0.42	0.24 - 0.44	0.38 - 0.46
Lead	1.1	0.014 - 0.16	0.0078 - 0.014	0.0050 - 0.0069	0.0073 - 0.017	0.0050 - 0.57	0.0078 - 0.018	0.0049 - 0.058	0.0050 - 0.034
Nickel	83	0.14 - 1.6	0.12 - 1.7	0.2 - 1.0	0.22 - 1.8	0.18 - 1.2	0.12 - 2.2	0.68 - 1.7	1.0 - 2.1
Silver ^(c)	0.94	0.0053 - 0.014	0.0048 - 0.015	0.0054 - 0.0080	0.0043 - 0.013	0.0052 - 0.0080	0.0043 - 0.042	0.0043 - 0.053	0.0049 - 0.021
Thallium	NA	0.0035 - 0.0072	0.0035 - 0.014	0.011 - 0.014	0.026 - 0.041	0.0085 - 0.026	0.0085 - 0.011	0.013 - 0.020	0.014 - 0.028
Zinc	55	1.1 - 5.0	0.76 - 1.7	2.7 - 3.7	1.7 - 3.4	0.35 - 2.1	1.1 - 1.8	1.3 - 2.9	1.7 - 3.0
No. of Samples		4	3	2	4	4	2	6	4
Total Recoverable Metals (µg/L)									
Chromium ^(d)	96	11 - 20	2.2 - 48	7.6 - 11	24 - 150	4.0 - 18	17 - 23	1.8 - 4.9	3.2 - 24
Mercury	0.012	0.00098 - 0.0013	0.00086 - 0.0015	0.00044 - 0.0006	0.00086 - 0.004	0.00065 - 0.002	0.0017 - 0.0038	0.00089 - 0.0026	0.00088 - 0.0047
Selenium	5	1.2 - 1.9	0.39 - 2.2	0.88 - 0.96	0.67 - 1.9	0.39 - 0.76	0.94 - 2.3	1.2 - 2.3	2.4 - 3.9
No. of Samples		4	2	2	7 ^(e)	6	4	6	4
Anions (mg/L)									
Nitrate	45 ^(f)	1.8 - 3.4	3.8 - 4.9	3.5 - 4.9	0.84 - 4.5	0.52 - 20	0.58 - 33	3.0 - 8.1	5.1 - 6.4

(a) Ambient Water Quality Criteria Values (WAC 173-201A-040) for chronic toxicity unless otherwise noted.

(b) Value for hexavalent chromium.

(c) Value for acute toxicity; chronic value not available.

(d) Value for trivalent chromium.

(e) One nitrate result of 295 mg/L for riverbank spring (SD-110-2) on October 17, 2000 was not included in the range because it was considered an anomalously high value.

(f) Drinking water standard (WAC 246-290).





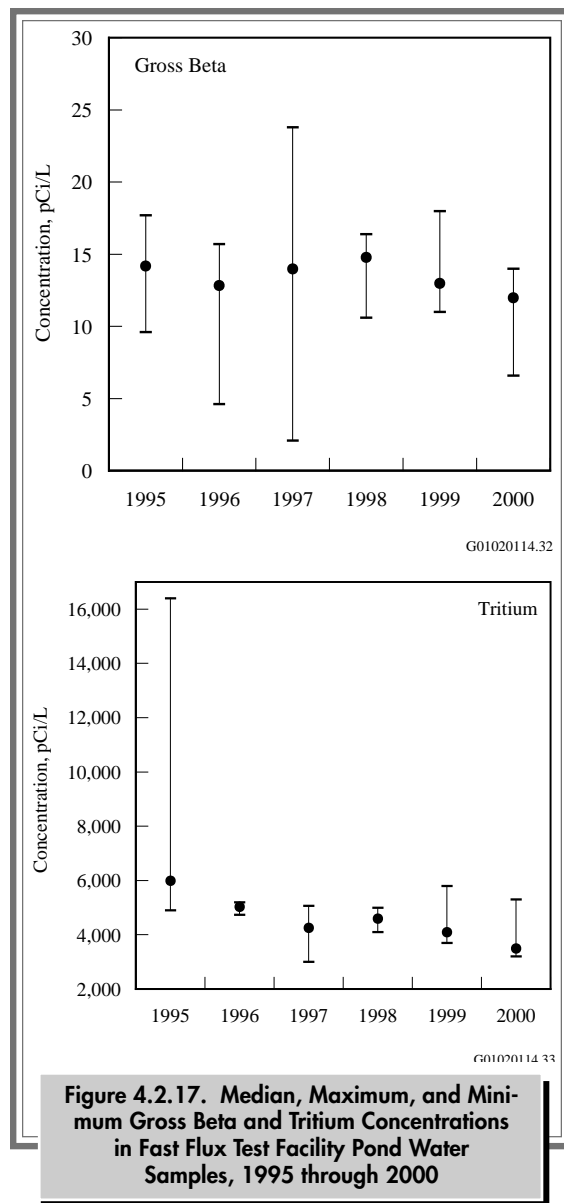
4.2.4.1 Collection of Pond Water Samples and Analytes of Interest

In 2000, grab samples were collected quarterly from the Fast Flux Test Facility pond and from West Lake. Unfiltered aliquots of all samples were analyzed for gross alpha and gross beta concentrations, gamma-emitting radionuclides, and tritium. West Lake samples were also analyzed for technetium-99 and uranium-234, -235, and -238. Constituents were chosen for analysis based on their known presence in local groundwater or in effluents discharged to the pond and their potential to contribute to the overall radiation dose to the public.

4.2.4.2 Radiological Results for Pond Water Samples

Analytical results from pond water samples collected during 2000 are reported in PNNL-13487, APP. 1. With the exceptions of uranium-234 and uranium-238 concentrations in samples from West Lake, radionuclide concentrations in onsite pond water were less than the DOE derived concentration guides (DOE Order 5400.5; see Appendix D, Table D.5). The median gross alpha, gross beta, and total uranium concentrations exceeded their ambient surface-water quality criteria in West Lake. The median concentrations of all other radionuclides were below ambient surface-water quality criteria levels (WAC 173-201A; 40 CFR 141; see Appendix D, Tables D.1 and D.2).

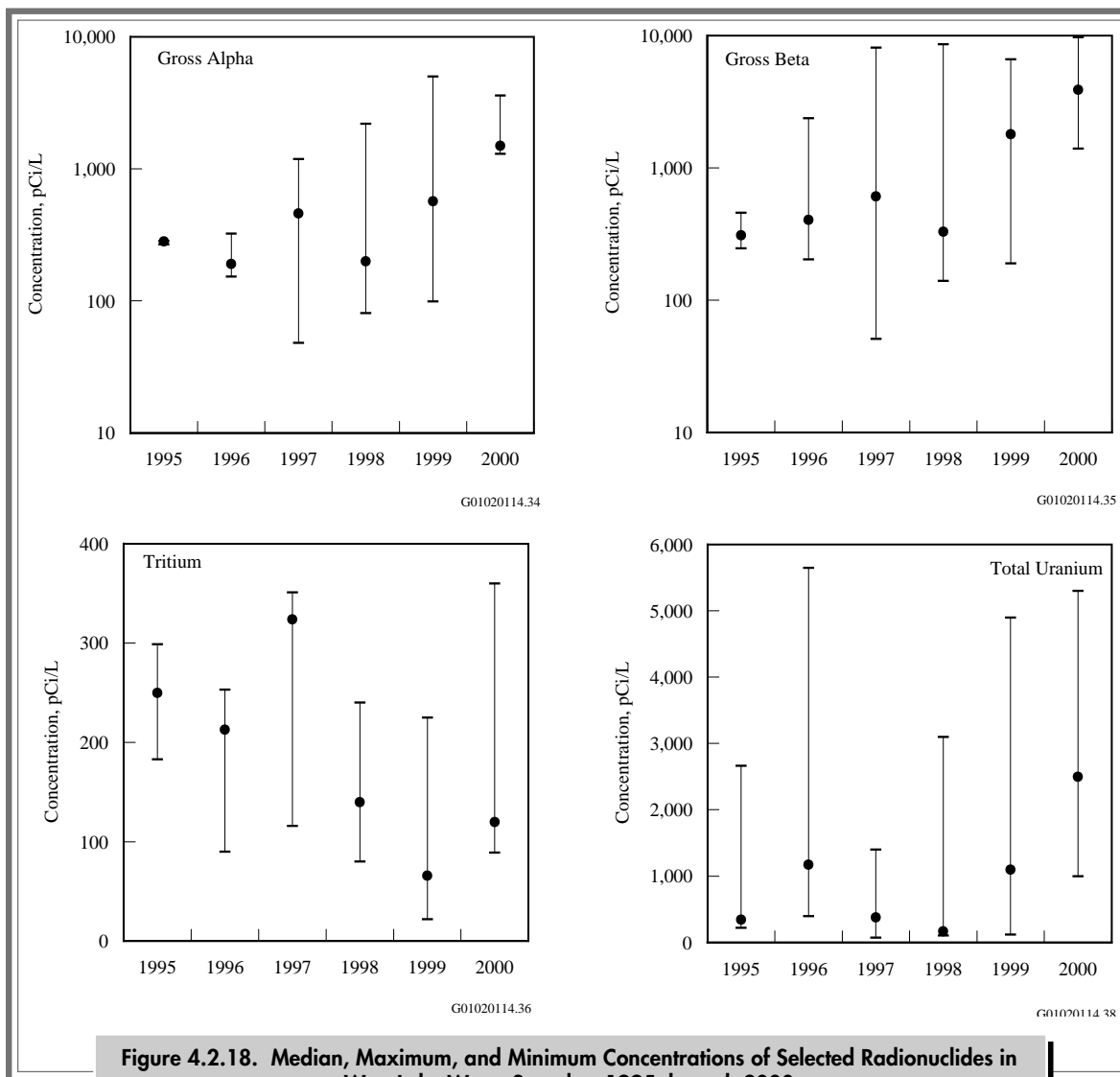
Figure 4.2.17 shows the annual gross beta and tritium concentrations in Fast Flux Test Facility pond water from 1995 through 2000. Median levels of both constituents have remained stable in recent years. However, the tritium concentration in the July 1995 sample was 16,400 pCi/L, which was much higher than that observed previously. The use of groundwater well 499-S0-7 during this time is most likely responsible for the high levels of tritium observed in



July 1995. Tritium levels in well 499-S0-7 are typically greater than 20,000 pCi/L, reflective of those observed in a portion of the local unconfined aquifer. Median gross beta and tritium concentrations in Fast Flux Test Facility pond water during 2000 were 24% and 18% of their respective ambient surface-water quality criteria. The concentrations of all other measured contaminants in this pond water were below detection limits, except for naturally occurring potassium-40.

The annual concentrations of selected radionuclides from 1995 through 2000 in West Lake water are shown in Figure 4.2.18. Median radionuclide concentrations in West Lake during 2000 were similar to those observed in the past. The gross alpha and gross beta levels in West Lake water are believed to result from high levels of naturally occurring uranium in the surrounding soil (BNWL-1979; PNL-7662). Annual median total uranium concentrations have remained stable over the last 6 years, but the range is large. The highest concentrations measured in 2000 were in the fall, when the water level in the pond was

low. It is thought that the relatively large concentration of suspended sediment in the samples is causing the elevated results. Similar total uranium levels were reported in PNNL-7662 for West Lake samples that contained high concentrations of suspended sediment. Because of the high suspended sediment concentrations, strontium-90 analyses for West Lake water samples were not conducted in 2000. Declines in groundwater levels beneath the 200 Areas have been recorded since the decommissioning of the processing ponds and the shutdown of production facilities (see Section 7.1). As a result, the water





level in West Lake has dropped. Median concentrations of tritium and technetium-99 in West Lake in 2000 were 0.60% and 44%, respectively, of the ambient surface-water quality criteria levels and reflected

local groundwater concentrations. The concentrations of all other measured radionuclides were below their detection limits, except for naturally occurring potassium-40.

4.2.5 Offsite Water

During 2000, water samples were collected from an irrigation canal located across the Columbia River at Riverview and downstream from the Hanford Site. This canal receives water pumped from the Columbia River near Pasco, Washington. In addition, one water sample was collected from the Horn Rapids irrigation pumping station located between the 300 Area and Richland. As a result of public concern about the potential for Hanford-associated contaminants in offsite water, sampling was conducted to document the levels of radionuclides in water used by the public. Consumption of vegetation irrigated with Columbia River water downstream of the site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical maximally exposed individual and any other member of the public (see Section 6.0).

4.2.5.1 Collection, Analysis, and Results for Irrigation Water

Water in the Riverview irrigation canal was sampled three times in 2000 during the irrigation

season. Unfiltered samples of the canal water were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, and uranium-234, -235, and -238. Results are presented in PNNL-13487, APP. 1. In 2000, radionuclide concentrations measured in this canal's water were at the same levels detected in the Columbia River. All radionuclide concentrations were below the DOE derived concentration guides and ambient surface-water quality criteria levels (DOE Order 5400.5; WAC 173-201A; 40 CFR 141). The strontium-90 levels in the irrigation water during 2000 ranged from 0.040 ± 0.030 to 0.073 ± 0.028 pCi/L and were similar to those reported for the Columbia River at Priest Rapids Dam and the Richland Pumphouse (see Section 4.2.1).

The water sample from the Horn Rapids irrigation pumping station was analyzed for the same analytes as the Riverview irrigation canal, except for tritium. All radionuclide concentrations were below both DOE derived concentration guides and ambient surface-water quality criteria levels (DOE Order 5400.5; WAC 173-201A; 40 CFR 141) and were similar to Columbia River concentrations (see Section 4.2.1).